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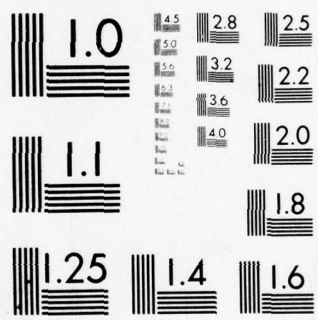

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TECHNICAL REPORT ARBRL-TR-02053

CALCULATION OF COMBAT VEHICLE PROTECTION AGAINST A RESIDUAL RADIATION THREAT

Albert E. Rainis
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April 1978

US ARMY ARMAMENT RESEARCH AND DEVELOPMENT COMMAND
BALLISTIC RESEARCH LABORATORY
ABERDEEN PROVING GROUND, MARYLAND

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Gamma protection factors (GPF) for two medium tanks have been calculated using the Monte Carlo program, MORSE. Comparisons with appropriate experiments show good agreement. It is concluded that this calculational approach is a viable alternative to experiment for determining the GPFs of armored vehicles.

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I. PURPOSE

The purpose of this report is to describe a calculational method which can be employed to provide a quantitative measure of the increased survivability of personnel in combat vehicles against the external radiation exposure threat posed by residual radiation. Comparisons with certain applicable experiments are made in order to assess the accuracy of the technique.

II. INTRODUCTION

A. Background

Residual radiation can pose a military threat. Under certain meteorological and/or weapon employment conditions, radioactive fallout from a weapon burst could be of such a localized character so as to cause areas of intense radiation. The extent and intensities of these radiation fields can be mapped by troops utilizing the appropriate equipment. Alternately, with some information on the conditions pertaining to the weapon burst and the prevailing winds, the fallout patterns can be predicted by the battle field commander.[1] Troops passing through or emplaced in these areas would be subjected to a radiation hazard. Their vulnerability can be reduced by a number of techniques which include physically removing the radioactive debris by scraping the surrounding ground or by utilizing the shielding afforded by armored vehicles. The concern here is the reduction of the fallout threat by armored vehicles.

The protection afforded by a combat vehicle against the gamma radiation from fallout can be quantified in terms of a gamma protection factor (GPF). The GPF for fallout radiation is defined as the ratio of the dose at an altitude of 3 feet in the absence of the vehicle (free field dose) to the dose at a position inside the vehicle. Clearly, the larger the overall GPF for a particular vehicle, the more protection it affords.

Heretofore, GPF values for these geometrically complicated military vehicles have been measured experimentally. One technique used to simulate the fallout threat against a variety of vehicles was a circulating point source of radiation.[2] These experiments modelled an envisioned scenario of an infinite-in-extent flat air/ground interface with the fallout source distributed uniformly on the ground. Two convenient

---

1 *J.C. Maloney and W.J. Klemm, "Department of Defense Land Fallout Prediction System", May 1975, BRL Report No. 1783, Ballistic Research Laboratory, APG-EA, MD.* (AD #B004148L)

2 *M.A. Schmoke and W.J. Post, "Residual Radiation Shielding Characteristics of the M60A1E2 Tank", October 1973, BRL Report No. 1678, Ballistic Research Laboratory, APG-AA, MD.* (AD #914673L)

isotopes, ^{60}Co and ^{137}Cs, were available to approximate the various stages in the radioactive decay of the fallout material.[3] ^{60}Co, however, was used preferentially since it represents the average energy gamma radiation present in fallout at early times.

Oak Ridge National Laboratory (ORNL) developed a three dimensional Monte Carlo radiation transport code, MORSE[4], which has the capability of handling complicated geometries via a combinatorial geometry (CG) package.[5] MORSE is an "off-the-shelf" computer code which has been successfully employed in the cost-effective solution of a number of diverse radiation transport problems such as reactor design and the shielding of military vehicles against initial radiation.[6] The successful application of MORSE to the problem of determining the amount of shielding afforded by combat vehicles against fallout radiation could be a viable economic alternative. It can be estimated that, relative to experimental measurements, monetary savings of about 70% could be realized in the absence of other considerations. However, since the mathematical models of the vehicles used for these calculations will have already been constructed for initial radiation calculations, the effective savings realized are even greater.

B. Calculational Approach

The scenario to be modelled in the calculations is the combat vehicle positioned at the interface of an infinite-in-extent air-over-ground environment. The source material (fallout) is assumed to be spread uniformly on the smooth interface. Figure 1 depicts the vicinity of the combat vehicle. In concert with previous experimental work, it is assumed that the gamma ray spectrum emitted by the fallout can be approximated by ^{60}Co.

A gamma ray emitted by the source distributed on the ground can interact with a crew member by following one of four paths: (a) direct,

---

3 *R.E. Rexroad and M.A. Schmoke, "A Point Source Circulating System for Simulating Fallout Gamma Radiation", December 1964, NDL-TM-15, Nuclear Defense Laboratory, APG-EA, MD.*

4 *M.B. Emmett, "The MORSE Monte Carlo Radiation Transport Code System", ORNL-4972, Oak Ridge National Laboratory, Oak Ridge, TN, 1975.*

5 *C.E. Bugart, "The Truth About Combinatorial Geometry Input", (1972), Unpublished SAI memo.*

6 *W.A. Rhoades, "Development of a Code System for Determining Radiation Protection of Armored Vehicles", 1974, ORNL-TM-4664, Oak Ridge National Laboratory, Oak Ridge, TN.*

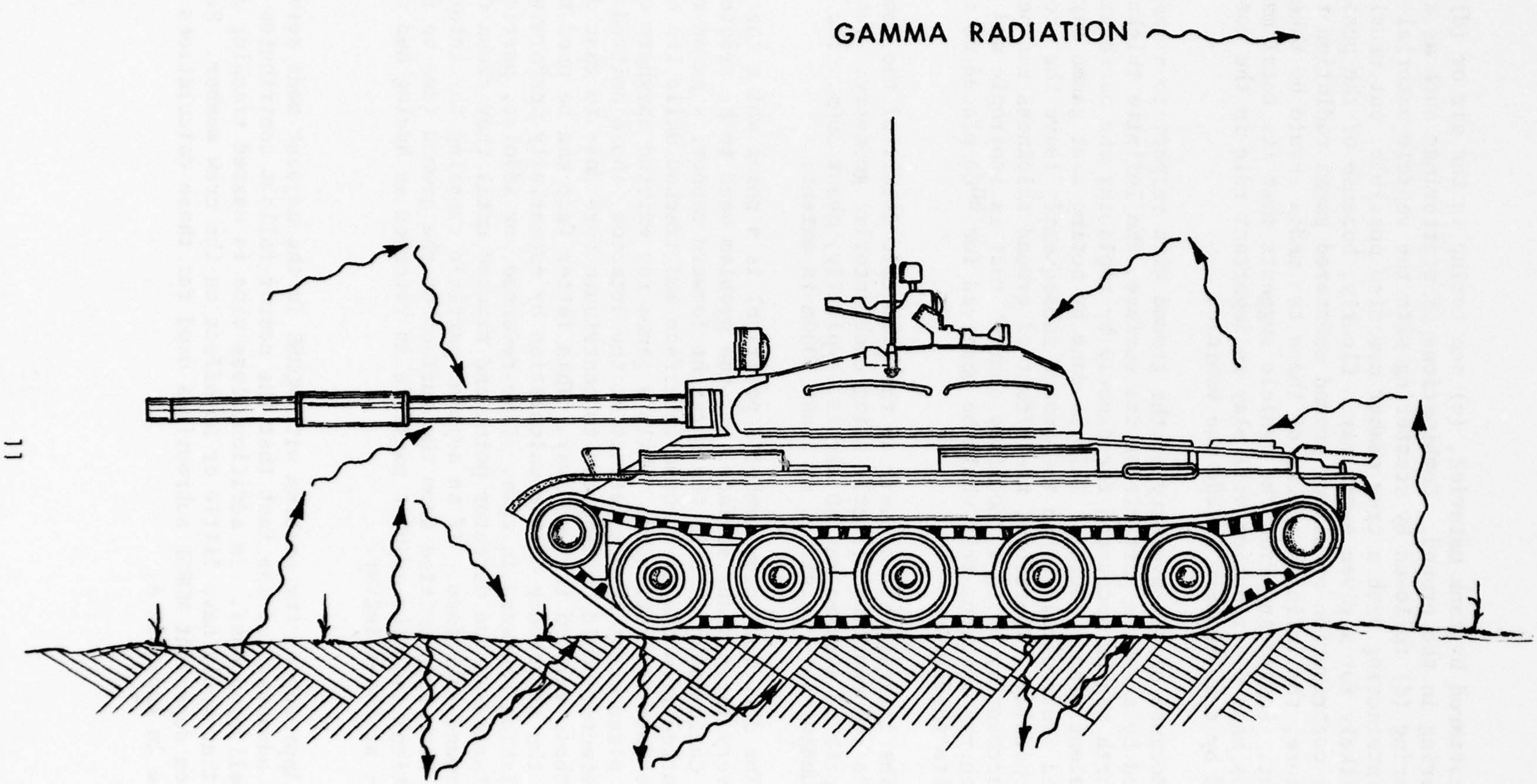

Figure 1. Vehicle in a Fallout Field.

(b) scattered by tank material, (c) scattering in the air or (d) scattering in the ground. Combinations of scatterings such as a ground scattering (d) followed by scattering with the vehicle material (b) before interacting with a crew member are also possible, but usually are less likely for a given gamma ray. Clearly, because of the possibility of the contribution of air or ground scattered gamma radiation to delivered dose, the infinite extent of these two media should be taken into account. Scattering from the vehicle suggests that its total mass as well as mass distribution will play an important role in the dose received by crew members inside the vehicle.

Because of the symmetry of the ground with respect to a gamma ray emitted by a source particle on its surface, the infinite thickness of the earth can be accounted for exactly by replacing the earth with an equivalent planar source. This is done by noting that gamma rays emitted isotropically into the ground subsequently leave the ground isotropically. Therefore, the effect of ground thickness can be taken into account by using a "modified source" that is isotropic and has the same energy spectrum that would be observed for ^{60}Co placed on earth of infinite thickness.

The infinite air as well as the geometric detail of the combat vehicle are modelled directly using combinatorial geometry. The mean free path of a gamma ray in air is, typically, about 300m. The air surrounding the vehicle is at least 3000m in extent.

The detector (crew member's position) is a point while the source is a very large plane surface. If the problem were to be treated via Monte Carlo techniques in the straight forward manner, a gamma-ray would be started from the air/ground interface and tracked while its effect on the dose was estimated. While a gamma ray emitted anywhere on this large plane might have an effect at the detector, those emitted near the detector would be expected to contribute more dose to that detector than those emitted farther away. This latter fact can be used to improve the efficiency of the calculation by essentially performing the calculation backward in time. Time-reversed, or adjoint, particles are started at the detector point and tracked until they cross the air/ground interface. If an adjoint particle crossing the interface would have been emitted from the surface of the ground (due to fallout radiation) then the adjoint particle is recorded as having had an effect at the detector.

Approaching the problem with MORSE in the adjoint mode automatically takes advantage of the fact that the nearer fallout contributes most to the delivered dose. In addition, less time is wasted tracking gamma rays that would have little or no effect on the crew member. Several problem dependent MORSE subroutines used for these calculations are listed in Appendix A.

The gamma ray data, material cross-sections, and Auxier-Snyder fluence-to-dose conversion factors were taken from the DNA 37-21 library.[7] The atomic composition of the air and soil are listed in Table I.

III. RESULTS

A. Ground Scattered Spectrum

Gamma rays with an isotropic distribution were started from a point source of ^{60}Co on the surface of a cube of soil one kilometre on a side. All the gamma rays exiting from the surface of the cube were scored as to energy and importance (statistical weight). These exiting gamma rays included those which scattered from within the cube of soil.

Table II contains the energy bin structure of the gamma rays from the DNA 37-21 group set. Notice that the two gamma rays of ^{60}Co, 1.17 and 1.33 MeV, are both within energy group 11. Figure 2 presents the results of the above calculation. In Figure 2 it is seen that 50% of the leakage gamma radiation has an energy equal to the primary energy group. This would be expected since half of the gamma rays are emitted away from the soil cube. Furthermore, the secondary peak at approximately 200 keV is due to backscattered radiation (large angle scattering) which has an increased probability of escaping the cube of soil.

B. Free Field Calculations

The spectrum presented in Figure 2 appears reasonable; however, another check to determine whether it will adequately represent the leakage spectrum for the case of interest can be performed. Simulated fallout fields have been studied by a number of workers.[8,9] Reference 9 contains semi-empirical data for the free field dose rate at various heights above a fallout field simulated with a point source of ^{60}Co.

Figure 3 presents a plot of these data versus height. The line through these points is intended solely as a guide. Plotted also are

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7 *D.E. Bartine, J.R. Knight, J.V. Pace and R.W.Roussin, "Production and Testing of the DNA Few Groups Cross Section Library", October 1975, ORNL - TM-4840, Oak Ridge National Laboratory, Oak Ridge, TN.*

8 *Schumchyk, et al., "Measurements of Gamma Radiation and Gamma Spectra versus Height Above a Fallout Field Simulated with ^{60}Co", November 1965, NDL-TR-70, Nuclear Defense Laboratory, APG-EA, MD.*

9 *Schumchyk, et al., "Scattered Radiation (Skyline) Contribution to an Open Basement Located in a Simulated Fallout Field", December 1966, NDL-TR-68, Nuclear Defense Laboratory, APG-EA, MD.*

Table I. Atomic Composition of Air and Soil

Element	Atomic Density (atoms/barn-cm)
Air	
Oxygen	1.1229-5*
Nitrogen	4.19948-5
Argon	2.51482-7
Ground	
Oxygen	3.47950-2
Silicon	1.15967-2
Aluminum	4.88019-3
Hydrogen	9.75181-3

* Read as 1.1229 $\times 10^{-5}$

Table II. Gamma Ray Energy Group Structure

Group Number	Upper Edge (eV)
1	1.4 + 7*
2	1.0 + 7
3	8.0 + 6
4	7.0 + 6
5	6.0 + 6
6	5.0 + 6
7	4.0 + 6
8	3.0 + 6
9	2.5 + 6
10	2.0 + 6
11	1.5 + 6
12	1.0 + 6
13	7.0 + 5
14	4.5 + 5
15	3.0 + 5
16	1.5 + 5
17	1.0 + 5
18	7.0 + 4
19	4.5 + 4
20	3.0 + 4
21	2.0 + 4
	1.0 + 4

*Read as 1.4×10^7

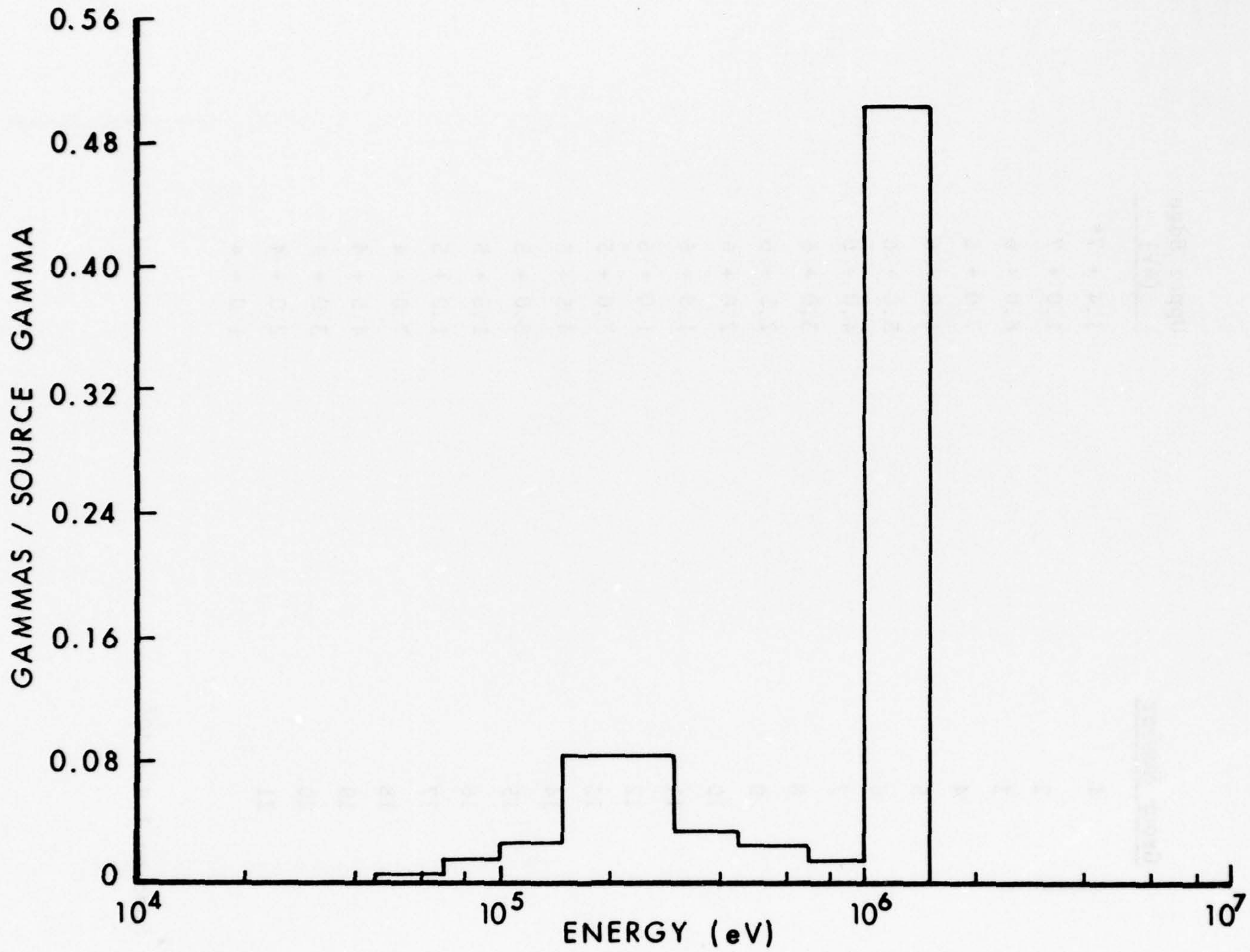

Figure 2. Gamma Spectrum from ^{60}Co on a Smooth Semi-Infinite Cube of Soil

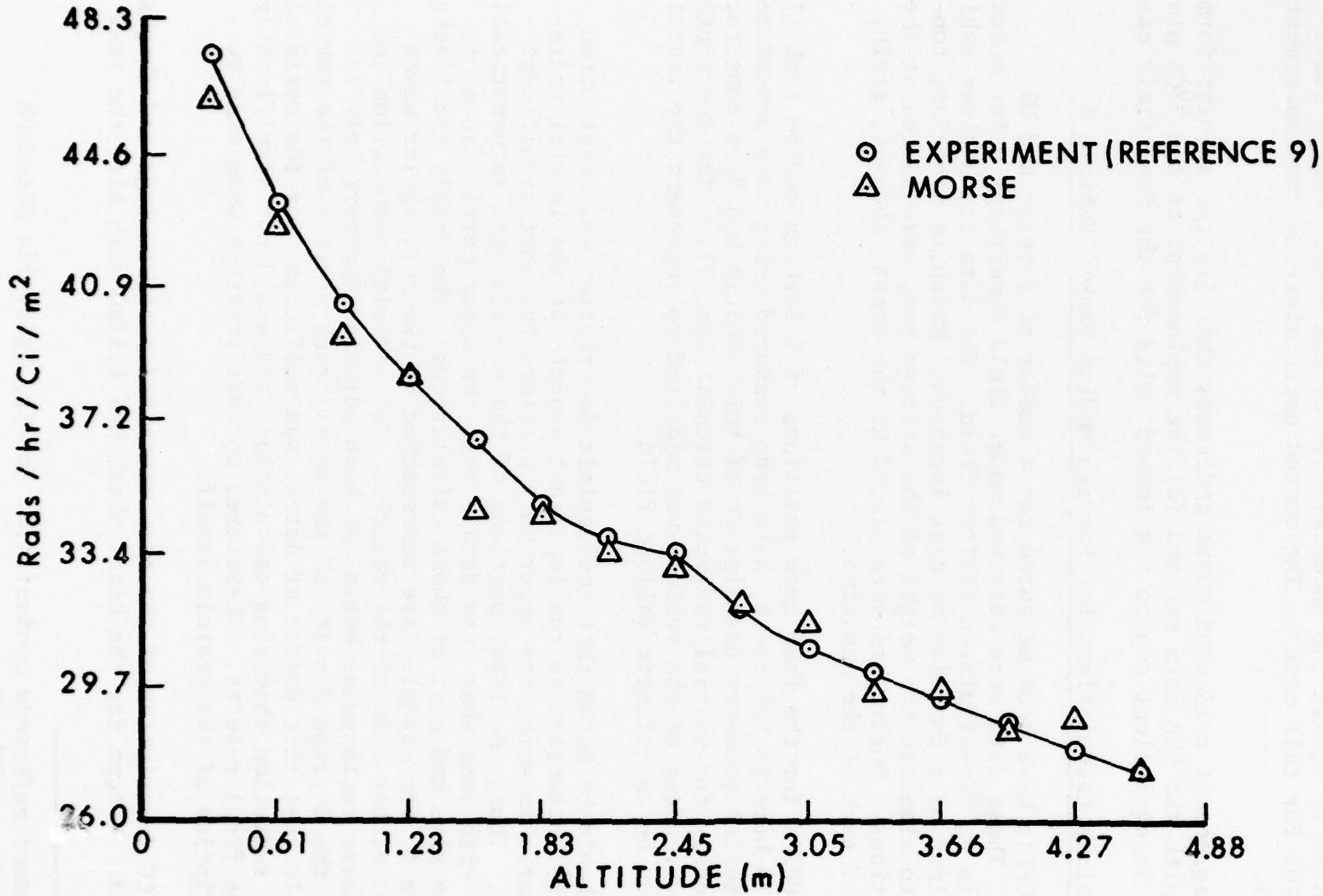

Figure 3. Dose Rate Above a ^{60}Co Simulated Fallout Field

the results of 15 adjoint MORSE calculations for the dose rate as a function of height over an infinite, smooth plane. Note that the agreement is excellent. The greatest difference (the point at five feet) is only 5% which is within the uncertainties of the MORSE results (estimated at 10% for this case). The quoted uncertainty on the experimental data is 6%.

The agreement evidenced above indicates that (1) the adjoint form of MORSE with the DNA data set and (2) the replacement of the ^{60}Co plus soil with an equivalent source are indeed valid for the free field case.

C. In-Vehicle Calculations for Foreign Medium Tank: Vehicle A

The GPF's have been measured for a number of foreign and US vehicles. These data were obtained under field conditions using actual vehicles in a ^{60}Co-simulated fallout field. The data for a given vehicle were obtained as a function of crew location. Masonite manikins, constructed to simulate the weight of the average man, were placed at the crew positions. Dosimeters were placed at the chest, abdomen, groin, and back of each of the manikins.

The GPF's for the four crew positions of a foreign medium tank (10), referred to here as Vehicle A, have been measured using this procedure. A combinatorial geometry description of this vehicle had been constructed previously for initial radiation calculations (11). The description of the environment of the vehicle was modified to represent the vehicle as situated on an infinite fallout field.

It should be noted that the vehicle description was constructed with careful attention to the important aspects of the initial radiation scenario in which the upper hull provides the most significant shielding. Thus, the lower portions of the vehicle were mathematically described with some what less detail than the upper portion so as to reduce the time and cost of those calculations. The wheels and tracks of Vehicle A, for example, are represented by two rectangular boxes located on either side of the vehicle. The material composition and mass of these rectangular boxes had been adjusted appropriately to represent the average density of the wheel/track portion of the vehicle. It was felt that this degree of detail was sufficient for the residual (fallout) radiation shielding calculations and would not significantly affect the final results. Therefore, no modifications were made to the description of the vehicle itself.

The CG description of the crew contained a torso, legs and thighs and a head. Except for the head, which was filled with air, the rest

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10 *For exact reference contact A.E. Rainis, Ballistic Research Laboratory, APG, MD.*

11 *For exact reference contact A.E. Rainis, BRL, APG, MD.*

of the body used the composite "man" material described in Reference 11. The GPF was calculated at four locations in and near crew members of Vehicle A: just outside the center of the chest (front), the center of the back, inside the air filled head, and mid torso. This was done to assess the effect of the GPF on the location of the detector position.

Figure 4 presents a comparison of the gamma energy spectra in-vehicle (loader's position) and free field. Note that the primary shape differences are in the low energy region below 200 keV. This type of behavior is what might be expected since the photoelectric absorption cross section for iron increases rapidly with decreasing energy below 200 keV. [12]

The calculated values of the GPF for the above locations and the average measured values are shown in Table III. The uncertainty limits on the experimentally determined average GPFs reflect both the experimental error and the spread of the values of the GPFs measured at the different locations on the manikin. The values of the fractional standard deviation (fsd) given for the calculated values provide a calculational "figure-of-merit". That is, they are a measure only for the stochastic nature of the calculation and not necessarily an estimate of the discrepancy with the "true" value.

The mid-torso detector location is observed to compare favorably with the experimental average values. The largest observed difference for these comparisons is less than 20%, with the calculated GPFs always within the experimental uncertainty limits. Table III also shows that air-detector calculations (front, back and head) generally lie close to one another but, with one exception, are lower than the mid-torso calculations and the experimental average. However, with the exception of the driver's position, the experimental uncertainties and the calculated GPFs with their associated fsd show agreement. Note that the calculated GPFs for the mid-torso location of the gunner's and loader's positions have fsd values which are twice that of the calculations for the detectors in air. This occurs because of the location of the detector inside the mid-torso. From this viewpoint, a detector position in air is desirable. Of the three in-air locations utilized for these calculations, the center of the air head is the most easily identifiable in the combinatorial geometry description. Therefore, both for calculational convenience and ease of reproducibility, the air head location will be employed as the standard position for future calculations.

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[12] *J.H. Hubbell and M.J. Berger, "Photon Attenuation Absorption Coefficients: Tabulation and Discussion", September 1966, NBS 8681, National Bureau of Standards.*

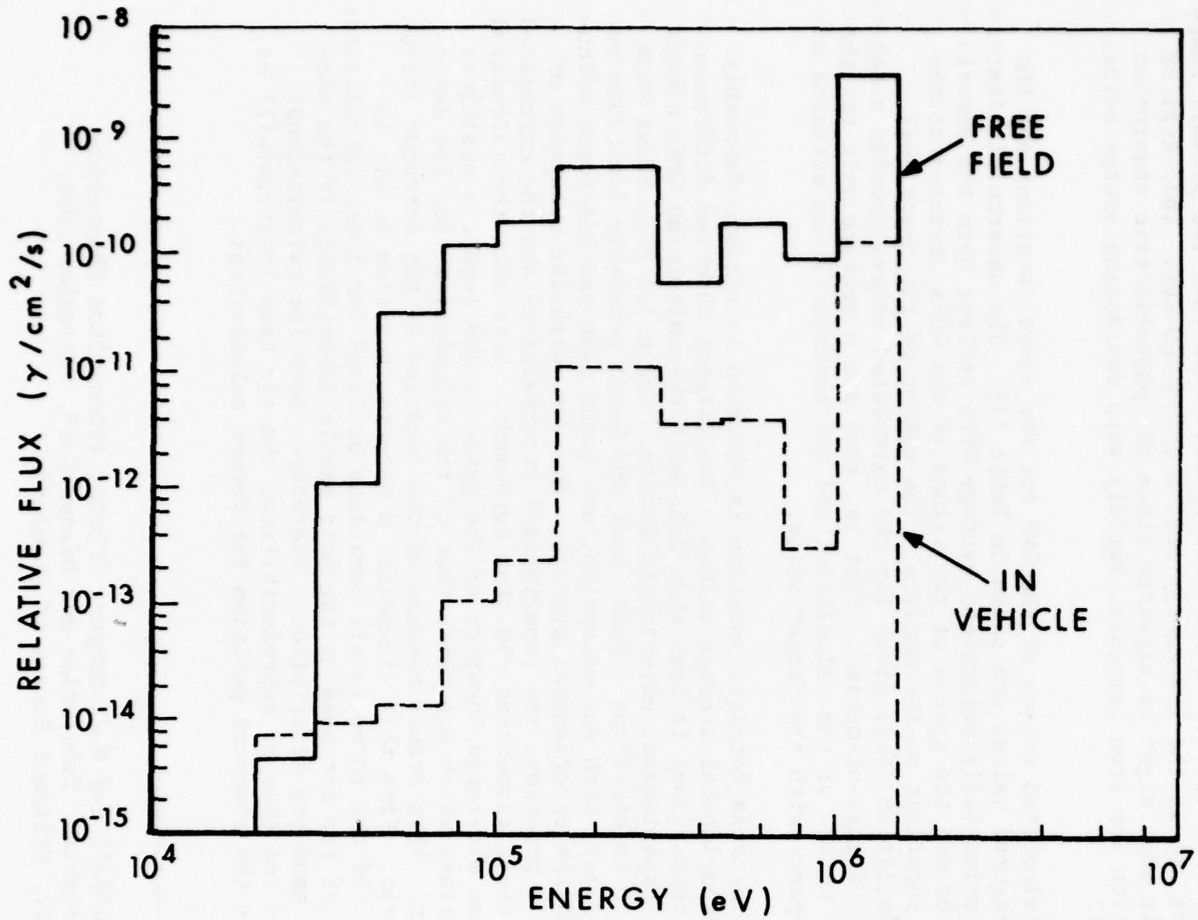

Figure 4. Free Field and In-vehicle Gamma Energy Spectra for Vehicle A.

Table III. Experimental/Calculated Values of the GPF for Vehicle A*

Detector Location	Crew Position: Driver	Gunner	Commander	Loader
Front (Calculated)	16	26	24	23
Back (Calculated)	17	27	27	22
Head (Calculated)	16	29	26	28
Mid Torso (Calculated)	18	25**	34	25**
Mid Torso (Experimental)***	22±18%	29±21%	33±15%	31±28%

* fsd is less than 10% for the in-vehicle dose rate calculations except as noted.

** fsd is 20% for the in-vehicle dose rate calculations.

***For exact reference contact A.E. Rainis, Ballistic Research Laboratory, APG, MD 21005.

D. In-Vehicle Calculations For Foreign Medium Tank: Vehicle B

Calculations for another vehicle were performed to further test the correlation of an air head detector location for the calculations. The values of the GPF for the crew of this vehicle (referred to as Vehicle B) have also been measured previously.[13] Additionally, a CG description of the vehicle, previously used for initial radiation calculations, was also available.[14] This description was modified only to the extent described in the previous section for Vehicle A. The results of the experiments and these calculations are presented in Table IV.

Note that the average GPF for all positions in the experiment and the calculation agree with each other despite the fact that the experimental numbers are based on detectors placed about the torso while the the detector location for the calculations is in the head. The correspondence of these values demonstrates that the GPF for an air-head detector is similiar to the average GPF of detectors placed about the body. This reinforces the use of the air-head location for future calculations.

Examining the GPF values for the individual crew positions, one finds that the calculated values for the driver position appear to be low when compared to the experimental results. This may be due to limited detail of the lower portion of the vehicle. Because the location of the driver is closer to the source of radiation and the "smeared" wheels and track than the other locations, the GPF for that position would be expected to be the most sensitive to differences between the actual vehicle and the description employed for the calculations.

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13 *For exact reference, contact A.E. Rainis, Ballistic Research Laboratory, Aberdeen Proving Ground, MD.*

14 *For exact reference, contact A.E. Rainis, Ballistic Research Laboratory, Aberdeen Proving Ground, MD.*

Table IV. Experimental/Calculated GPF's for Vehicle B

	Experiment		Calculation	
Crew Position	Body Average	Range	Air Head	fsd(%)
Commander	29	25-32	34	10
Loader	30	23-34	30	16
Gunner	30	20-39	33	18
Driver	24	20-26	15	11
Overall Average	28		28	

IV. CONCLUSIONS

The described calculational technique can be employed to calculate values of the GPF for the crew of military vehicles. Using the comparisons between calculations and experiments on the same vehicles, a conservative confidence limit of 20% can be assigned to the calculated values of the GPF. For convenience, the air-head is adopted as the detector location for future calculations.

APPENDIX A

Problem Dependent MORSE Subroutines

The computer code, MORSE, used for these calculations was, in the main, the standard version distributed by RSIC.[4] Several subroutines necessary for dose estimation are problem dependent and have to be user supplied. The subroutines peculiar to this problem are included in Tables A1-A3.

Table A1. MORSE Subroutine BANKR

```
      SUBROUTINE BANKR(NBNKID)
C  DO NOT CALL EUCLID FROM BANKR(7)
      COMMON /APOLLO/ AGSTRT,DDF,DEADWT(5),ETA,ETATH,ETAUSD,UINP,VINP,       20
     1 WINP,STSTRT,XSTRT,YSTRT,ZSTRT,TCUT,XTRA(10),                          30
     2   IO,I1,MEDIA,IADJM,ISBIAS,ISOUR,ITERS,ITIME,ITSTR,LOCWTS,LOCFWL,BANKR 40
     3 LOCEPR,LOCNSC,LOCFSN,MAXGP,MAXTIM,MEDALB,MGPREG,MXREG,NALB,      BANKR 50
     4 NDEAD(5),NEWNM,NGEOM,NGPWT1,NGPQT2,NGPQT3,NGPQTG,NGPQTN,NITS,    BANKR 60
     5 NKCALC,NKILL,NLAST,NMEN,NMGP,NMOST,NMTG,NOLEAK,NORMG,NPAST,      BANKR 70
     6 NPSCL(13),NQUIT,NSIDL,NSOUR,NSPLT,NSTRT,NXTRA(10)                BANKR 80
      COMMON /NUTRON/ NAME,NAMEX,IG,IGO,NMED,MEDOLD,NREG,U,V,W,UOLD,VOLDBANKR 90
     1 ,WOLD,X,Y,Z,XOLD,YOLD,ZOLD,WATE,OLDWT,WTBC,BLZNT,BLZON,AGE,OLDAGEBANK 100
      NBNK = NBNKID                                                     BANK 110
      IF (NBNK) 100,100,140                                             BANK 120
  100 NBNK = NBNK + 5                                                   BANK 130
      GO TO (104,103,102,101),NBNK                                      BANK 140
  101 CALL STRUN                                                        BANK 150
      CALL HELP(4HSTRU,1,1,1,1)
      RETURN                                                            BANK 160
  102 NBAT = NITS - ITERS                                               BANK 170
      NSAVE = NMEM                                                      BANK 180
      CALL STBTCH(NBAT)                                                 BANK 190
C  NBAT IS THE BATCH NO. LESS ONE
     RETURN                                                             BANK 200
  103 CALL NBATCH (NSAVE)                                               BANK 210
C  NSAVE IS THE NO. OF PARTICLES STARTED IN THE LAST BATCH
     RETURN                                                             BANK 220
C    CALL WRTCD(NBNK,1,NMGP,NMPQTN,NGPQTG,IADJM)
```

Table A1. MORSE Subroutine BANKR (Continued)

```
  104 CONTINUE                                                              BANK 230
      CALL NRUN(NITS NQUIT)                                                 BANK 240
C   NITS IS THE NO. OF BATC HES COMPLETED IN THE RUN JUST COMPLETED
C   NQUIT .GT. 1 IF MORE RUNS REMAIN
C         .EQ. 1 IF THE LAST SCHEDULED RUN HAS BEEN COMPLETED
          IS THE NEGATIVE OF THE NO. OF COMPLETE RUNS  WHEN AN
                EXECUTION TIME KILL OCCURS
    RETURN                                                                  BANK 250
  140 GO TO (1,2,3,4,5,6,7,8,9,10,11,12,13), NBNK                           BANK 260
C  NBNKID    COLL TYPE    BANKR CALL      NBNKID    COLL TYPE   BANKR CALL
C     1       SOURCE      YES (MSOUR)        2       SPLIT       NO  (TESTW)
C     3       FISSION     YES (FPROB)        4       GAMGEN      YES (GSTORE)
C     5       REAL COLL   YES (MORSE)        6       ALBEDO      YES (MORSE)
C     7       BDRYX       YES (NXTCOL)       8       ESCAPE      YES (NXTCOL)
C     9       E-CUT       NO  (MORSE)       10       TIME KILL   NO  (MORSE)
```

Table A1 MORSE Subroutine BANKR (Continued)

```
C   11      R R KILL   NO  (TESTW)      12       R R SURV   NO  (TESTW)
C   13      GAMLOST    NO  (GSTORE)
C  1 CALL SDATA
 1   RETURN                                                         BANK 290
   2 RETURN                                                         BANK 300
   3 RETURN
C  4 CALL SGAM
 4   RETURN
C  5 CALL RELCOL                                                    BANK 340
 5   RETURN
   6 RETURN
C
C * * * USE HOME MADE SURFACE CROSSING ESTIMATOR.

   7 CALL SXE
   8 RETURN                                                         BANK 360
   9 RETURN                                                         BANK 370
  10 RETURN                                                         BANK 380
  11 RETURN                                                         BANK 390
  12 RETURN                                                         BANK 400
  13 RETURN                                                         BANK 410
     END                                                            BANK 420
```

Table A2. MORSE Subroutine

```
      FUNCTION DIREC(X)                                                 DIREC 10
      COMMON /USER/ DUM(9),IO,I1,IDUM(12)                               DIREC 20
      COMMON /NUTRON/ NAME,NAMEX,IG,IGO,NMED,MEDOLD,NREG,U,V,W,UOLD,VOLD
     1 WOLD,XT,Y,Z,XOLD,YOLD,ZOLD,WATE,OLDWT,WTBC,BLZNT,BLZON,AGE,OLDAGE
      DATA ICALL/1/                                                     DIREC 30
      IF (ICALL) 10,10,5                                                DIREC 40
    5 ICALL = 0                                                         DIREC 50
      WRITE (10,1000)                                                   DIREC 60
 1000 FORMAT(  YOU ARE USE THE VERSION OF DIREC WHICH BIASES THE ',
     $ PARTICLES TO THE  -Z DIRECTION ACCORDING TO W (DIR. COS).')
   10 DIREC = -1. W
      RETURN                                                            DIRE 100
      END                                                               DIRE 110
```

Table A3. MORSE Subroutine SXE

```
      SUBROUTINE SXE
C
C     SURFACE CROSSING EXTIMATOR FOR MORSE.INFINITE AIR/PLANE CASE
C
C*********************************************************************
C     ASSUMES A SQUARE SCORING SURFACE OF DIMENSION 'RAD' (=3.0+8 CM)
C     WHICH IS PARALLEL TO THE X-Y PLANE AT A HEIGHT 'ZC' (=0.0) AND
      IS MADE UP OF MEDIUM 1000. THE AREA IS RAD**2
C**********************************************************************
     COMMON /PDET/ ND,NNE,NE,NT,NA,NRESP,NEX,NEXND,NEND,NDNR,NTNR,NTNE,
    1 NANE,NTNDNR,NTNEND,NANEND,LOCRSP,LOCXD,LOCIB,LOCCO,LOCT,LOCUD,
    2 LOCSD,LOCQE,LOCQT,LOCQTE,LOCQAE,LMAX,EFIRST,EGTOP
     COMMON /NUTRON/ NAME,NAMEX,IG,ICO,NMED,MEDOLD,NREG,U,V,W,UOLD,VOLD
    1 WOLD,X,Y,Z,XOLD,YOLD,ZOLD,WATE,OLDWT,WTBC,BLZNT,BLZON,AGE,OLDAGE
     COMMON/DETCUT/NDC
      COMMON NL(1)
      DATA RAD,ZC,AREA        /3.0E8 0.005 9.0E16/
C * * * CHECK TO SEE IF CROSSING IS FOR DETECTOR SURFACE.
      IF((Z-ZC).GT.0.0)GO TO 1
C * * * COS IS ABS(N*OMEGA) UNLESS IT IS A GRAZING ANGLE.
      COS=ABS(W)
      IF (COS.LT.0.01) COS=0.005
C * * * CALCULATE FLUENCE ESTIMATE.
      CON = WATE/AREA/COS

C * * * STORE ESTIMATE AND ACCUMULATE THE NUMBER OF SAME.
      CALL FLUXST(1,IG,CON,0.0,0.0,1)
      NL(LOCXD+6*ND+1)=NL(LOCXD+6*ND+1)+1
 1    RETURN
      END
```

APPENDIX B

Run Stream for a Typical Calculation

A listing of the input and controls cards for a typical problem is presented for the MORSE Code as implemented on the UNIVAC 1108 Computer.

Appendix B. Run Stream for a Typical Calculation

```
@ASG A  GMA-XSET
@USE 3.' GMA-XSET.
@XQT SABRE *TFF.RUN
 ADJOINT GAMMA.  VEHICLE-B.  COMMANDER HEAD.
200,500,300,1,0,21,21,21,0,1,220., 8,0
0,21,1,0,1.,1.0-5,1.0+4,0.,2.2+5
-60.96,49.53,145.89,0,0,0,0
0.,0.,0.,0.,0.
0.,0.,0.,0.,0.,6.41-10,4.82-10
3.60-10,2.48-10,1.64-10,1.01-10,7.44-11,7.73-11,1.17-10
2.23-10,6.26-10
1.,1.,1.,1.,1.,1.,1.,1.,1.,1.
5.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.
.14+8,.10+8,.80+7 .70+7,.60+7,.50+7,.40+7,.30+7,.25+7
.200+7,.15+7,.10+7,.70+6,.45+6,.30+6,.15+6,.10+6,.70+5,.45+5,.30+5,.20+5
   021711770667
1,1,0,0,0,1,21
1,1,21,0,1,0
11.,1.-3 5.-1,0.5
-1,0,0,0,0,0
0,0,0,0,0
0,0,0,0

  RPP    1     -1.+6        1.+6       -1.+6        1.+6       -1.+6        1.+6
  TRC    2    -20.320      -2.540      97.790        .000        .000      71.120
              123.190      82.550        .000        .000        .000        .000
  TRC    3    -20.320      -2.540      97.790        .000        .000      67.183
              111.760      73.660        .000        .000        .000        .000
  ARB    4    109.220     -40.640     146.050     -20.320     -85.090     168.910
              -20.320      80.010     168.910     109.220      35.560     146.050
              109.220     -40.640      97.790     -20.320     -85.090      97.790
              -20.320      80.010      97.790     109.220      35.560      97.790
             1234.000    5678.000    3487.000    1265.000    2376.000    1485.000
  ARB    5    109.220      35.560     146.050     109.220     -40.640     146.050
              129.540     -46.990      97.790     129.540      41.910      97.790
              109.220      35.560      97.790     109.220     -40.640      97.790
              129.540     -46.990      97.790     129.540      41.910      97.790
             1234.000    1265.000    3456.000    3267.000    4518.000    4518.000
```

Appendix B. Run Stream for a Typical Calculation (Continued)

ARB	6	-20.320	80.010	168.910	109.220	35.560	146.050
		129.540	41.910	97.790	-20.320	120.650	97.790
		-20.320	80.010	97.790	109.220	35.560	97.790
		129.540	41.910	97.790	-20.320	120.650	97.790
		1265.000	4158.000	3267.000	5678.000	4128.000	3247.000
ARB	7	-20.320	-85.090	168.910	109.220	-40.640	146.050
		129.540	-46.990	97.790	-20.320	-125.730	97.790
		-20.320	-85.090	97.790	109.220	-40.640	97.790
		129.540	-46.990	97.790	-20.320	-125.730	97.790
		1265.000	4158.000	3267.000	5678.000	4128.000	3247.000
ARB	8	-20.320	-76.200	164.973	93.980	-33.020	140.970
		93.980	27.940	140.970	-20.320	71.120	164.973
		-20.320	-76.790	97.790	93.980	-33.020	97.790
		93.980	27.940	97.790	-20.320	71.120	97.790
		1234.000	5678.000	3487.000	1265.000	2376.000	1485.000
ARB	9	93.980	27.940	140.970	93.980	-33.020	140.970
		111.760	-43.180	97.790	111.760	38.100	97.790
		93.980	27.940	97.790	93.980	-33.020	97.790
		111.760	-43.180	97.790	111.760	38.100	97.790
		1234.000	1265.000	3456.000	3267.000	4518.000	4518.000
ARB	10	-20.320	71.120	164.973	93.980	27.940	140.970
		111.760	38.100	97.790	-20.320	109.220	97.790
		-20.320	71.120	97.790	93.980	27.940	97.790
		111.760	38.100	97.790	-20.320	109.220	97.790
		1265.000	4158.000	3267.000	5678.000	4128.000	3247.000
ARB	11	-20.320	-76.200	164.973	93.980	-33.020	140.970
		111.760	-43.180	97.790	-20.320	-114.300	97.790
		-20.320	-76.200	97.790	93.980	-33.020	97.790
		111.760	-43.180	97.790	-20.320	-114.300	97.790
		1265.000	4158.000	3267.000	5678.000	4128.000	3247.000

Appendix B. Run Stream for a Typical Calculation (Continued)

TRC	12	31.750	-2.540	125.222	450.596	.000	.000
		15.240	6.350	.000	.000	.000	.000
RCC	13	31.750	-2.540	125.222	450.596	.000	.000
		5.004	.000	.000	.000	.000	.000
RCC	14	.000	.000	94.615	.000	.000	3.175
		91.440	.000	.000	.000	.000	.000
TRC	15	.000	.000	97.790	.000	.000	-17.780
		125.730	100.584	.000	.000	.000	.000
ARB	16	243.840	93.980	.000	243.840	93.980	63.398
		294.005	90.932	34.036	294.005	90.932	34.036
		243.840	-93.980	.000	243.980	-93.980	63.398
		294.005	-90.932	34.036	294.005	-90.932	34.036
		3124.000	7658.000	1375.000	2376.000	1265.000	1265.000
ARB	17	243.840	88.900	12.192	243.840	88.900	52.222
		275.717	88.900	33.401	275.717	88.900	33.401
		243.840	-88.900	12.192	243.840	-88.900	52.222
		275.717	-88.900	33.401	275.717	-88.900	33.401
		3124.000	7658.000	1375.000	2376.000	1265.000	1265.000
ARB	18	243.840	100.584	.000	243.840	100.584	63.398
		177.800	100.584	102.057	177.800	100.584	.000
		243.840	-100.584	.000	243.840	-100.584	63.398
		177.800	-100.548	102.057	177.800	-100.584	.000
		1234.000	5678.000	3487.000	1265.000	2376.000	1485.000
ARB	19	243.840	92.710	2.032	243.840	92.710	52.222
		177.800	92.710	90.881	177.800	92.710	2.032
		243.840	-92.710	2.032	243.840	-92.710	52.222
		177.800	-92.710	90.881	177.800	-92.710	2.032
		1234.000	5678.000	3487.000	1265.000	2376.000	1485.000
BOX	20	177.800	-100.584	.000	-410.972	.000	.000
		.000	201.168	.000	.000	.000	97.790
BOX	21	177.800	-92.710	2.032	-410.972	.000	.000
		.000	185.420	.000	.000	.000	92.583

Appendix B. Run Stream for a Typical Calculation (Continued)

ARB	22	-233.172	100.584	97.790	-311.912	100.584	97.790
		-286.004	100.584	17.526	-233.172	100.584	.000
		-233.172	-100.584	97.790	-311.912	-100.584	97.790
		-286.004	-100.584	17.526	-233.172	-100.584	.000
		1234.000	5678.000	3487.000	1265.000	2376.000	1485.000
ARB	23	-233.172	92.710	94.615	-306.832	92.710	94.615
		-281.610	92.710	18.034	-233.172	92.710	2.032
		-233.172	-92,710	94.615	-306.832	-92.710	94.615
		-281.610	-92.710	18.034	-233.172	-92.710	2.032
		1234.000	5678.000	3487.000	1265.000	2376.000	1485.000
BOX	24	-124.460	-92.710	94.615	.762	.000	.000
		.000	185.420	.000	.000	.000	-92.583
RCC	25	184.05	-152.527	-1.762	0.	305.054	0.
		40.386					
RCC	26	74.77	-152.527	-1.762	0.	305.054	0.
		40.386					
RCC	27	-20.574	-152.527	-1.762	0.	305.054	0.
		40.386					
RCC	28	-105.918	-152.527	-1.762	0.	305.054	0.
		40.386					
RCC	29	-193.04	-152.527	-1.762	0.	305.054	0.
		40.386					
RPP	30	-240.	230.	-111.887	111.887	-45.	40.
BOX	31	-5.842	12.700	150.622	37.592	.000	.000
		.000	-30.480	.000	.000	.000	-40.132
BOX	32	-20.320	127.000	97.790	127.000	.000	.000
		.000	-254.000	.000	.000	.000	72.000
BOX	33	208.280	-21.590	9.906	-119.380	.000	.000
		.000	30.480	.000	.000	.000	59.436
BOX	34	-52.070	-72.390	11.430	-53.340	.000	.000
		.000	-17.018	.000	.000	.000	71.120

Appendix B. Run Stream for a Typical Calculation (Continued)

ARB	35	274.320	8.890	32.258	209.550	8.890	70.866
		209.550	8.890	9.906	239.522	8.890	9.906
		274.320	-91.440	32.258	209.550	-91.440	70.866
		209.550	-91.440	9.906	239.522	-91.440	9.906
		1234.000	5678.000	2376.000	1265.000	3487.000	1485.000
BOX	36	209.550	-21.590	70.866	-57.150	.000	.000
		.000	-69.850	.000	.000	.000	-60.960
BOX	37	-168.148	76.200	31.750	31.496	.000	.000
		.000	-127.000	.000	.000	.000	-19.812
ARB	38	-139.700	76.200	57.150	-165.100	76.200	57.150
		-165.100	-50.800	57.150	-139.700	-50.800	57.150
		-125.730	76.200	31.750	-179.070	76.200	31.750
		-179.070	-50.800	31.750	-125.730	-50.800	31.750
		1234.000	5678.000	1265.000	2376.000	3487.000	4158.000
RCC	39	-223/520	76.200	31.750	.000	-152.400	.000
		27.940	.000	.000	.000	.000	.000
ARB	40	-258.318	82.804	94.615	-306.832	82.804	94.615
		-258.750	82.804	33.020	-258.318	82.804	33.020
		-258.318	68.580	94.615	-306.832	68.580	94.615
		-258.750	27.940	33.020	-258.318	27.940	33.020
		1234.000	5678.000	1265.000	2376.000	3487.000	1485.000
BOX	41	-264.160	-102.870	93,980	185.928	.000	.000
		.000	-55.880	.000	.000	.000	-19.050
BOX	42	100.330	-102.870	93.980	90.170	.000	.000
		.000	-55.880	.000	.000	.000	-19.050
BOX	43	5.080	-125.222	93.980	50.292	.000	.000
		.000	-32.258	.000	.000	.000	-19.050
RCC	44	69.088	-29.210	65.278	70.104	.000	.000
RCC	45	69.088	-29.210	48.768	70.104	.000	.000
		6.452	.000	.000	.000	.000	.000
RCC	46	69.088	-29.210	33.020	70.104	.000	.000
		6.452	.000	.000	.000	.000	.000

Appendix B. Run Stream for a Typical Calculation (Continued)

RCC	47	69.088	-29.210	17.526	70.104	.000	.000
		6.452	.000	.000	.000	.000	.000
RCC	48	69.088	-44.450	80.772	70.104	.000	.000
		6.452	.000	.000	.000	.000	.000
RCC	49	69.088	-44.450	65.278	70.104	.000	.000
		6.452	.000	.000	.000	.000	.000
RCC	50	69.088	-44.450	48.768	70.104	.000	.000
		6.452	.000	.000	.000	.000	.000
RCC	51	69.088	-44.450	33.020	70.104	.000	.000
		6.452	.000	.000	.000	.000	.000
RCC	52	69.088	-44.450	17.526	70.104	.000	.000
		6.452	.000	.000	.000	.000	.000
RCC	53	69.088	-61.468	80.772	70.104	.000	.000
		6.452	.000	.000	.000	.000	.000
RCC	54	69.088	-61.468	65.278	70.104	.000	.000
		6.452	.000	.000	.000	.000	.000
RCC	55	69.088	-61.468	48.768	70.104	.000	.000
		6.452	.000	.000	.000	.000	.000
RCC	56	69.088	-61.468	33.020	70.104	.000	.000
		6.452	.000	.000	.000	.000	.000
RCC	57	69.088	-61.468	17.526	70.104	.000	.000
		6.452	.000	.000	.000	.000	.000
RCC	58	69.088	-76.200	71.882	70.104	.000	.000
		6.452	.000	.000	.000	.000	.000
RCC	59	69.088	-76.200	56.642	70.104	.000	.000
		6.452	.000	.000	.000	.000	.000
RCC	60	69.088	-76.200	40.386	70.104	.000	.000
		6.452	.000	.000	.000	.000	.000
RCC	61	69.088	-76.200	24.130	70.104	.000	.000
		6.452	.000	.000	.000	.000	.000
RCC	62	53.340	-82.804	64.008	-70.104	.000	.000
		6.452	.000	.000	.000	.000	.000

Appendix B. Run Stream for a Typical Calculation (Continued)

RCC	63	-38.100	-82.804	48.514	70.104	.000	.000
		6.452	.000	.000	.000	.000	.000
RCC	64	53.340	-82.804	32.766	-70.104	.000	.000
		6.452	.000	.000	.000	.000	.000
RCC	65	-38.100	-82.804	16.510	70.104	.000	.000
		6.452	.000	.000	.000	.000	.000
RCC	66	-81.280	85.090	59.182	70.104	.000	.000
		6.452	.000	.000	.000	.000	.000
RCC	67	79.502	85.090	48.006	-70.104	.000	.000
		6.452	.000	.000	.000	.000	.000
RCC	68	-91.948	30.480	79.502	.000	-70.104	.000
		6.452	.000	.000	.000	.000	.000
RCC	69	-84.328	30.480	66.040	.000	-70.104	.000
		6.452	.000	.000	.000	.000	.000
RCC	70	-100.076	-60.960	66.040	.000	70.104	.000
		6.452	.000	.000	.000	.000	.000
RCC	71	-84.328	-60.960	50.800	.000	70.104	.000
		6.452	.000	.000	.000	.000	.000
RCC	72	-100.076	30.480	50.800	.000	-70.104	.000
		6.452	.000	.000	.000	.000	.000
RCC	73	-84.328	30.480	36.068	.000	-70.104	.000
		6.452	.000	.000	.000	.000	.000
RCC	74	-100.076	-60.960	36.068	.000	70.104	.000
		6.452	.000	.000	.000	.000	.000
RCC	75	-91.948	-60.960	22.860	.000	70.104	.000
		6.452	.000	.000	.000	.000	.000
RCC	76	-107.950	30.480	22.860	.000	-70.104	.000
		6.452	.000	.000	.000	.000	.000
RCC	77	-100.076	30.480	9.906	.000	-70.104	.000
		6.452	.000	.000	.000	.000	.000

Appendix B. Run Stream for a Typical Calculation (Continued)

RCC	78	-115.570	-60.960	9.906	.000	70.104	.000
		6.452	.000	.000	.000	.000	.000
RCC	79	-69.850	-60.960	25.400	.000	70.104	.000
		6.452	.000	.000	.000	.000	.000
RCC	80	-89.408	-81.280	109.220	68.148	-16.408	.000
		6.452	.000	.000	.000	.000	.000
RCC	81	-86.360	-66.040	127.000	68.148	-16.408	.000
		6.452	.000	.000	.000	.000	.000
RCC	82	-85.090	-37.592	152.908	.000	70.104	.000
		6.452	.000	.000	.000	.000	.000
RCC	83	-96.520	32.512	144.780	.000	-70.104	.000
		6.452	.000	.000	.000	.000	.000
RCC	84	-103.632	-37.592	132.588	.000	70.104	.000
		6.452	.000	.000	.000	.000	.000
RCC	85	-109.220	32.512	118.872	.000	-70.104	.000
		6.452	.000	.000	.000	.000	.000
RCC	86	-113.030	32.512	104.394	.000	-70.104	.000
		6.452	.000	.000	.000	.000	.000
SPH	87	-60.960	49.530	145.890	10.000	.000	.000
BOX	88	-71.120	31.750	135.890	20.320	.000	.000
		.000	35.560	.000	.000	.000	-63.500
RCC	89	-60.960	28.575	135.890	35.560	.000	-61.595
		3.175	.000	.000	.000	.000	.000
RCC	90	-60.960	70.485	135.890	35.560	.000	-61.595
		3.175	.000	.000	.000	.000	.000
RCC	91	-50.800	38.100	78.740	33.020	.000	.000
		6.350	.000	.000	.000	.000	.000
RCC	92	-50.800	60.960	78.740	33.020	.000	.000
		6.350	.000	.000	.000	.000	.000
RCC	93	-21.590	38.100	78.740	.000	.000	-35.560
		3.810	.000	.000	.000	.000	.000

Appendix B. Run Stream for a Typical Calculation (Continued)

RCC	94	-21.590	60.960	78.740	.000	.000	-35.560
		3.810	.000	.000	.000	.000	.000
BOX	95	-35.560	53.020	72.390	-30.480	.000	.000
		.000	33.020	.000	.000	.000	-2.794
BOX	96	-71.374	30.480	110.998	-3.048	.000	.000
		.000	38.100	.000	.000	.000	5.080
SPH	97	-4.318	49,530	138.270	10.000	.000	.000
BOX	98	-14.478	31.750	128.270	20.320	.000	.000
		.000	35.560	.000	.000	.000	-63.000
RCC	99	-4.318	28.575	128.270	61.595	.000	-35.560
		3.175	.000	.000	.000	.000	.000
RCC	100	-4.318	70.485	128.270	61.595	.000	-35.560
		3.175	.000	.000	.000	.000	.000
RCC	101	5.842	38.100	71.120	33.020	.000	.000
		6.350	.000	.000	.000	.000	.000
RCC	102	5.843	60.960	71.120	33.020	.000	.000
		6.350	.000	.000	.000	.000	.000
RCC	103	35.052	38.100	71.120	.000	.000	-35.5[illegible]
		3.810	.000	.000	.000	.000	.000
RCC	104	35.052	60.960	71.120	.000	.000	-35.560
		3.810	.000	.000	.000	.000	.000
BOX	105	-10.160	31.750	64.516	30.480	.000	.000
		.000	36.068	.000	.000	.000	-3.810
SPH	106	-48.260	-42.418	143.350	10.000	.000	.000
BOX	107	-58.420	-60.198	133.350	20.320	.000	.000
		.000	35.560	.000	.000	.000	-63.500
RCC	108	-48.260	-63.373	133.350	61.595	.000	-35.560
		3.175	.000	.000	.000	.000	.000
RCC	109	-48.260	-21.463	133,350	61.595	.000	-35.560
		3.175	.000	.000	.000	.000	.000
RCC	110	-38.100	-53.848	76.200	33.020	.000	.000
		6.350	.000	.000	.000	.000	.000
RCC	111	-38.100	-30.988	76.200	33.020	.000	.000
		6.350	.000	.000	.000	.000	.000

Appendix B. Run Stream for a Typical Calculation (Continued)

RCC	112	-8.890	-53.848	76.200	.000	.000	-35.560
		3.810	.000	.000	.000	.000	.000
RCC	113	-8.890	-30.988	76.200	.000	.000	-35.560
		3.810	.000	.000	.000	.000	.000
RCC	114	-42.672	-42.418	68.326	.000	.000	-2.540
		13.970	.000	.000	.000	.000	.000
BOX	115	-58.674	-52.578	69.850	-1.778	.000	.000
		.000	20.320	.000	.000	.000	38.100
SPH	116	143.510	58.928	78.580	10.000	.000	.000
BOX	117	133.350	41.148	68.580	20.320	.000	.000
		.000	35.560	.000	.000	.000	-62.230
RCC	118	143.510	37.973	68.580	61.595	.000	-35.560
		3.175	.000	.000	.000	.000	.000
RCC	119	143.510	79.883	68.580	61.595	.000	-35.560
		3.175	.000	.000	.000	.000	.000
RCC	120	153.670	47.498	12.700	33.020	.000	.000
		6.350	.000	.000	.000	.000	.000
RCC	121	153.670	70.358	12.700	33.020	.000	.000
		6.350	.000	.000	.000	.000	.000
RCC	122	186.690	47.498	12.700	33.020	.000	.000
		3.810	.000	.000	.000	.000	.000
RCC	123	186.690	70.358	12.700	33.020	.000	.000
		3.810	.000	.000	.000	.000	.000
BOX	124	128,524	40.640	3.556	38.100	.000	.000
		.000	36.830	.000	.000	.000	2.540
BOX	125	128,524	40.640	12.700	4.064	.000	.000
		.000	36.830	.000	.000	.000	40.640
RCC	126	83.000	.000	-76.990	.000	.000	30.000
		5.+5	.000	.000	.000	.000	.000
RCC	127	83.000	.000	-76.990	.000	.000	246.990
		5.+5					

Appendix B. Run Stream for a Typical Calculation (Continued)

```
END
 1        2    -3    -32
 2        4    -8    -9      -10    -11   -12
 3        5    -9    -10     -11    -12
 4        6   -10
 5        7   -11
 6   OR  12   -13OR  31
 7   OR   3   -31   -32      -80    -81   -82    -83   -84   -85
        -86   -87   -88      -89    -90   -96   -106  -107  -108
       -109  -115OR  8       -12    -31   -97    -98   -99  -100
       -108  -109OR  9       -12OR   10   -97    -98   -99  -100
     OR  11  -108
 8        1    13
 9       16   -18
10       18   -19
11   OR  15   -20OR  20      -21    -14   -88   -100  -107
12       22   -23
13       24    2;
14   OR  14   -88   -89      -90    -98   -99   -100  -107   -11
     OR  17   -35   -36OR    19     -33   -35    -36  -118  -119
       -120  -121  -122     -123OR   21   -24    -33   -34   -38
        -39   -44   -45      -46    -47   -48    -49   -50   -51
        -52   -53   -54      -55    -56   -57    -58   -59   -60
        -61   -62   -63      -64    -65   -66    -67   -68   -69
        -70   -71   -72      -73    -74   -75    -76   -77   -78
        -79   -88   -89      -90    -91   -92    -93   -94   -95
        -98
              -99  -100     -101   -102  -103   -104  -105  -107
       -110  -111  -112     -113   -114  -115   -116  -117  -118
       -119  -120  -121     -124   -125  -37OR   23   -39   -40
15       25   -30
16       26   -30
17       27   -30
```

Appendix B. Run Stream for a Typical Calculation (Continued)

18		28	-30							
19		29	-30							
20	OR	30	25	-18	-200R	30	26	-200R	30	27
		-200R	30	28	-200R	30	29	-20	-22	
21		32	-4	-5	-6	-7	-12			
22		1	33							
23		1	34							
24	OR	35	170R	35	190R	36				
25		37								
26		38								
27		39								
28		40	23							
29	OR	410R	42							
30		1	43							
31		127	-2	-4	-5	-6	-7	-12	-15	-16
		-18	-20	-22	-25	-26	-27	-28	-29	-32
		-41	-42	-43	-126					
32	OR	440R	450R	460R	470R	480R	490R	500R	510R	52
	OR	530R	540R	550R	560R	570R	580R	590R	600R	61
33	OR	620R	630R	640R	650R	660R	67			
34	OR	680R	690R	700R	710R	720R	730R	740R	750R	76
	OR	770R	780R	79						
35	OR	80	30R	81	30R	82	30R	83	30R	84
		30R	85	30R	86	30:				
36	OR	880R	890R	900R	910R	920R	930R	94		
37	OR	950R	96							
38	OR	980R	990R	1000R	1010R	1020R	1030R	104		
39		105								
40	OR	1070R	1080R	1090R	1100R	1110R	1120R	113		
41	OR	1140R	115							
42	OR	1170R	1180R	1190R	1200R	1210R	1220R	123		
43	OR	1240R	125							
44	OR	870R	970R	1060R	116					
45		126								
46		1	-127							
END										

```
 1    1    1    1    1    1    1    1    1    1    1    1    1    1
 1    1    1    1    1    1    1    1    1    1    1    1    1    1
 1    1    1    1    1    1    1    1    1    1    1    1    1    1

 1    1    1    1    1    1    1    1    1    1    1    1    1    1
 2    2    2    2    2    2    1    1    2    2    2    2    2    1
 4    4    4    4    4 1000    1    7    6    6    8    8    2    6
 6    6 1000    5    5    5    5    3    1    3    1    3    1    3
 1    1 1000    0
GAMMA  SET  1=AIR  2=ST  3=MN  4=TRK  5=AMMO  6=FUEL  7=BATT  8=ENG
0,0,21, 21, 58,61 ,4,8,7 ,8,4, 2,0
0,0,0,0, 0 ,0,0,-3, 0,0,0
ADJOINT  DETECTOR  RESPONSE.   (GROUND  SCORE)
1,0,21, 0,0,1,1,1
0,0,0
PARTICLE FLUX
PARTICLES
0.,0.,0.,0.,0.,0.,0.,0.,0.,0.,.50400,.013420,.02379,.03332,.08363
.02603,.01501,.004325,.00015,.000001,.0000001


PARTICLES/ENERGY BIN/EMITTED PARTICLE
1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21
```